# Grids for Dummies
# Featuring Earth Science Data Mining Application

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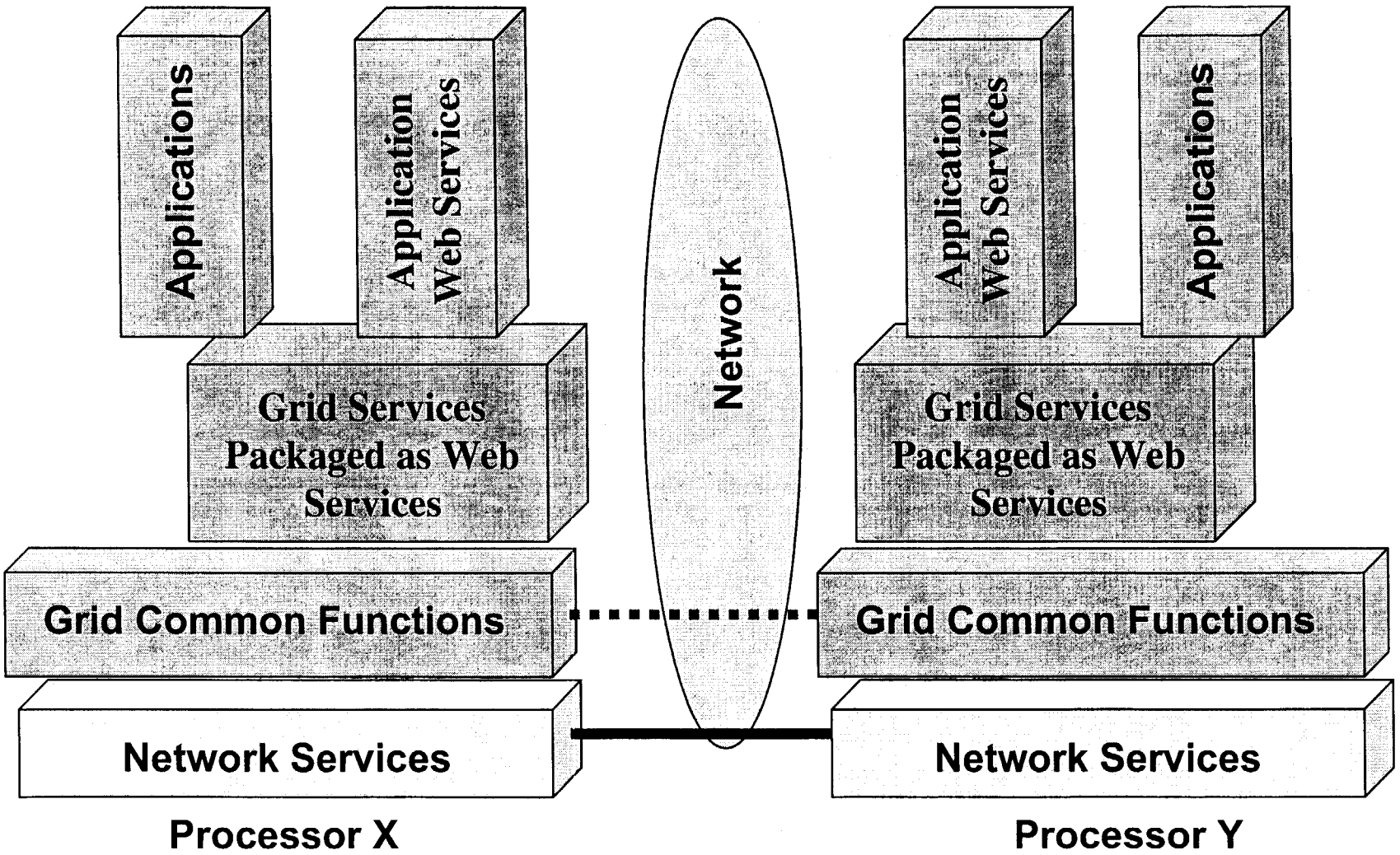
# Outline

- Use of Grids for Applications
  - What are grids
  - Grids from a user's perspective
  - Grid support for Earth Science applications such as data Mining
- Global Grid Forum
  - Background
  - Organization
  - Current work

# What are Grids?

- "Grids are persistent environments that enable software applications to integrate instruments, displays, computational and information resources that are managed by diverse organizations in widespread locations." [http://www.globus.org/]

# Middleware Makes the Grid



# Characteristics Usually Found in Grids

- An underlying security infrastructure such as the Grid Security Infrastructure (GSI), which is based on public key technology
  - Protection for at least authentication information as it flows from resource to resource
- Single sign-on
- A seamless processing environment
- An infrastructure that is scalable to a large number of resources
- The ability for the grid components to cross administrative boundaries

# Why are Grids Important?

- Computing and data Grids are emerging as the infrastructure for 21st century science, engineering and high-performance applications and systems
  - Grids provide a common way of managing distributed computing, data, instrument, and human resources
- Grids facilitate collaboration by providing the glue of large-scale science and engineering.
  - A common way to access and use shared data and simulations
  - A common security model to facilitate the interaction of many different people from many different institutions
- Grids provide a middle-ware environment that eases the development of complex systems.
  - Grids can facilitate the development of large-scale science, engineering and operational applications
    - That are widely distributed
    - That are processing and/or data intensive

# How the User Sees a Grid

- A set of grid functions that are available as
  - Application programer interfaces (APIs)
  - Command-line functions
- After authentication, functions can be used to
  - Spawn jobs on different processors with a single command
  - Access data on remote systems
  - Move data from one processor to another
  - Support the communication between programs executing on different processors
  - Discover the properties of computational resources available on the grid using the grid information service
  - Use a broker to select the best place for a job to run and then negotiate the reservation and execution (coming soon).

# What Will Grids Provide?

- Support for collaboration
  - Common authentication and security infrastructure
  - Common mechanisms to share data
  - Common mechanisms to access computing resources
  - Management of community databases
- Uniform data access
  - Standardized mechanisms for accessing archival datasets
  - Common mechanisms for managing metadata
- Support for building systems
  - Very few applications use a single computer
  - At least some of the resources needed to solve one's problem invariably reside elsewhere
  - Grids will supply the core capabilities common to most applications, so that application developers do not have to re-implement this core capability with each application

# Web Access to the Grid is Available

- Some web portals exist for accessing grids
  - LaunchPad
    - Developed as part of the NASA Information Power Grid project
    - Uses Java Server Pages and Java Beans
      - Built using the Grid Portal Development Kit
  - GridPort
    - Developed at the San Diego Super Computer Center
    - Uses Perl

# How an Application Developer Sees a Grid

- A set of grid functions
- A set of grid functions packaged as web services
  - Interface is defined through WSDL (Web Services Description Language)
  - Standard access protocol is SOAP (Simple Object Access Protocol)

# What a User Gains By Using a Grid

- As a direct user
  - Can easily
    - Execute jobs at one or more remote sites
    - Move data between sites
    - All with single sign on security
- As a user of a grid enabled application
    - Will not see the grid
    - Will see an application whose development was eased with grid functions or grid-based web services
    - Ease of development should result in more applications or faster availability of applications

# What Application Developers Gain by Using Grids

- Application web services can be built by re-using capabilities provided by existing grid-enabled Web services.
- Applications can also be built by using grid functions
- Grid functions/services handle distributed management of tasks and data
  - Developer can focus on logic of application and not logic of distributed interaction

# Grids Support Various Communities of Use

- **Scientists and domain problem solves and other users**
  - They will use the applications and services that the grid facilitates.
    - They need to be able to express a problem or experiment in application domain-specific terms, specify the drivers (initial conditions, live data sources, etc.) request that the solution **be obtained, and manage the resulting graphics, data, etc.**
- **Model builders and computational scientists**
  - They will use the grid directly to realize their models and simulations.
    - They combine knowledge of the real world with theoretic models of the real world to produce simulations or models that can produce a "complete" representation of the observables
- **Application developers**
  - They will use the grid directly to realize applications that require high performance computing or a large number of distributed processors.
  - They will use the models and simulations as components
- **Service builders**
  - They will build the frameworks that allow application developers to
    - Build grid services that can be used directly or
    - Use services as building blocks to more easily develop more complex services targeting specific application areas.

# Summary of What User Gains

- User can focus on solving domain issues of the problem and not on computer science issues of distributed computing

# Most Grids Are Built on the Globus Toolkit

- NASA's Information Power Grid (IPG) is one such example
- The Globus project involves research and development personnel from
  - Argonne National Laboratory
  - University of Southern California's Information Sciences Institute
  - NASA's Ames Information Power Grid Team
  - National Science Foundation PACI (Partnerships for Advanced Computational Infrastructure) programs at
    - National Center for Supercomputing Applications (NCSA)
    - San Diego Supercomputer Center
  - A number of universities

# Data Mining on the Grid

- What is data mining?
- Why mine on the Grid?
- The Grid Miner developed for NASA's Information Power Grid (IPG)
- A proposed IPG Mining Service

# What Is Data Mining

- "Data mining is the process by which information and knowledge are extracted from a potentially large volume of data using techniques that go beyond a simple search though the data." [NASA Workshop on Issues in the Application of Data Mining to Scientific Data, Oct 1999, http://www.cs.uah.edu/NASA_Mining/]

# Grid Miner

- Developed as one of the early applications on the IPG
  - Helped debug the IPG
  - Provided basis for satisfying one of two major IPG milestones last year
- Provides basis for what could be an on-going Grid Mining Service

# Example: Mining for Mesoscale Convective Systems

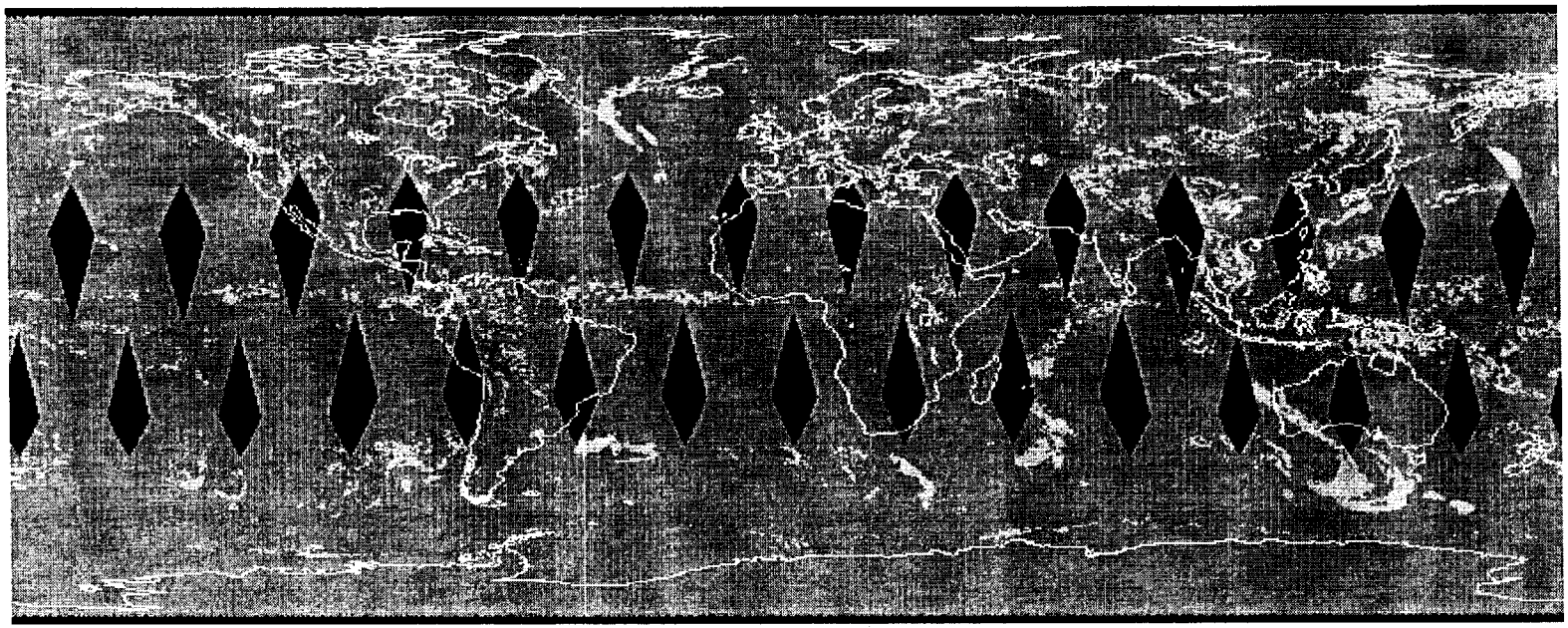


Image shows results from mining SSM/I data

# Example of Data Being Mined

- 75 MB for one day of global data - Special Sensor Microwave/Imager (SSM/I).
- Much higher resolution data exists with significantly higher volume.

# Grid Miner Operations

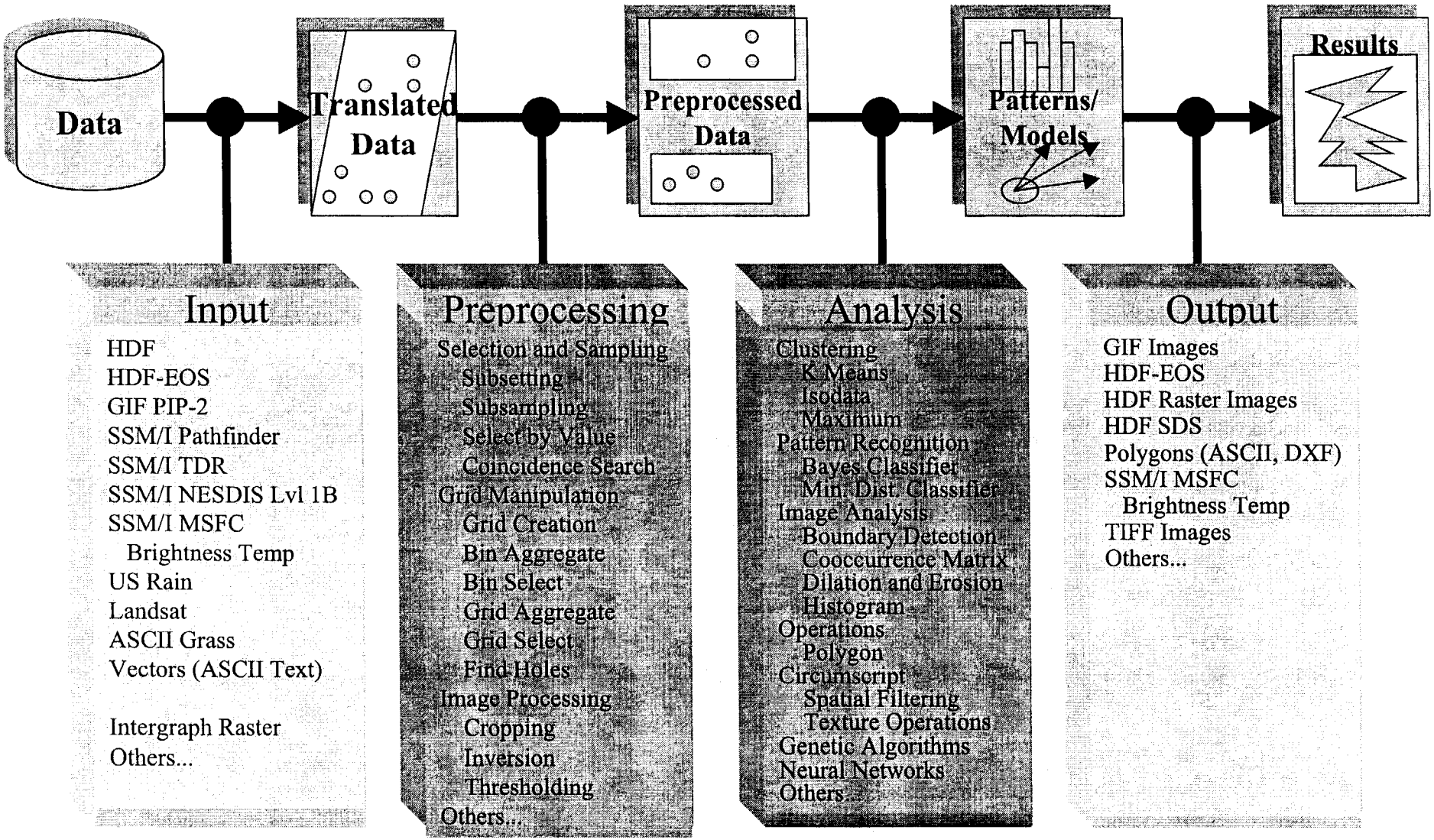
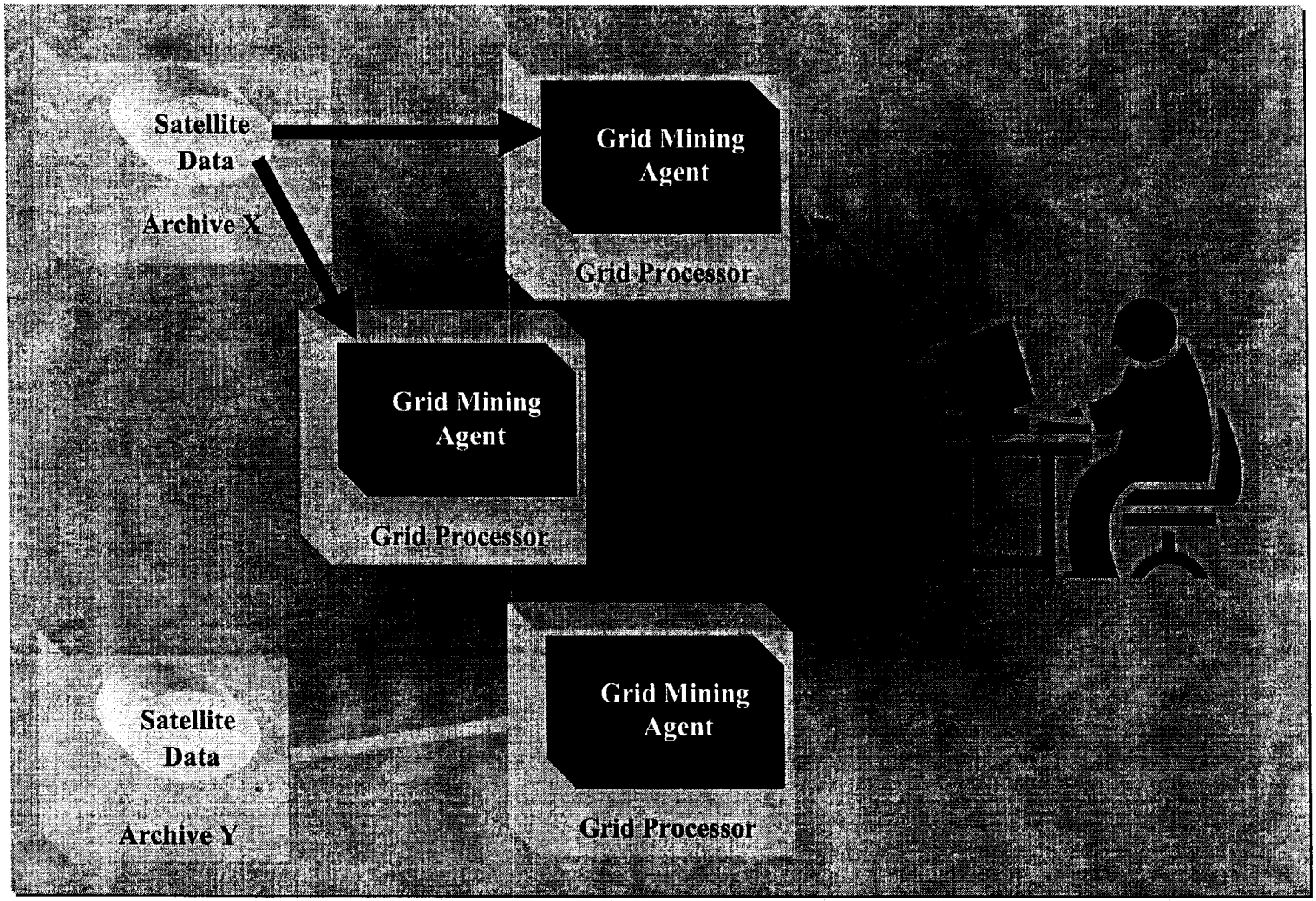



Figure thanks to Information and Technology Laboratory at the University of Alabama in Huntsville

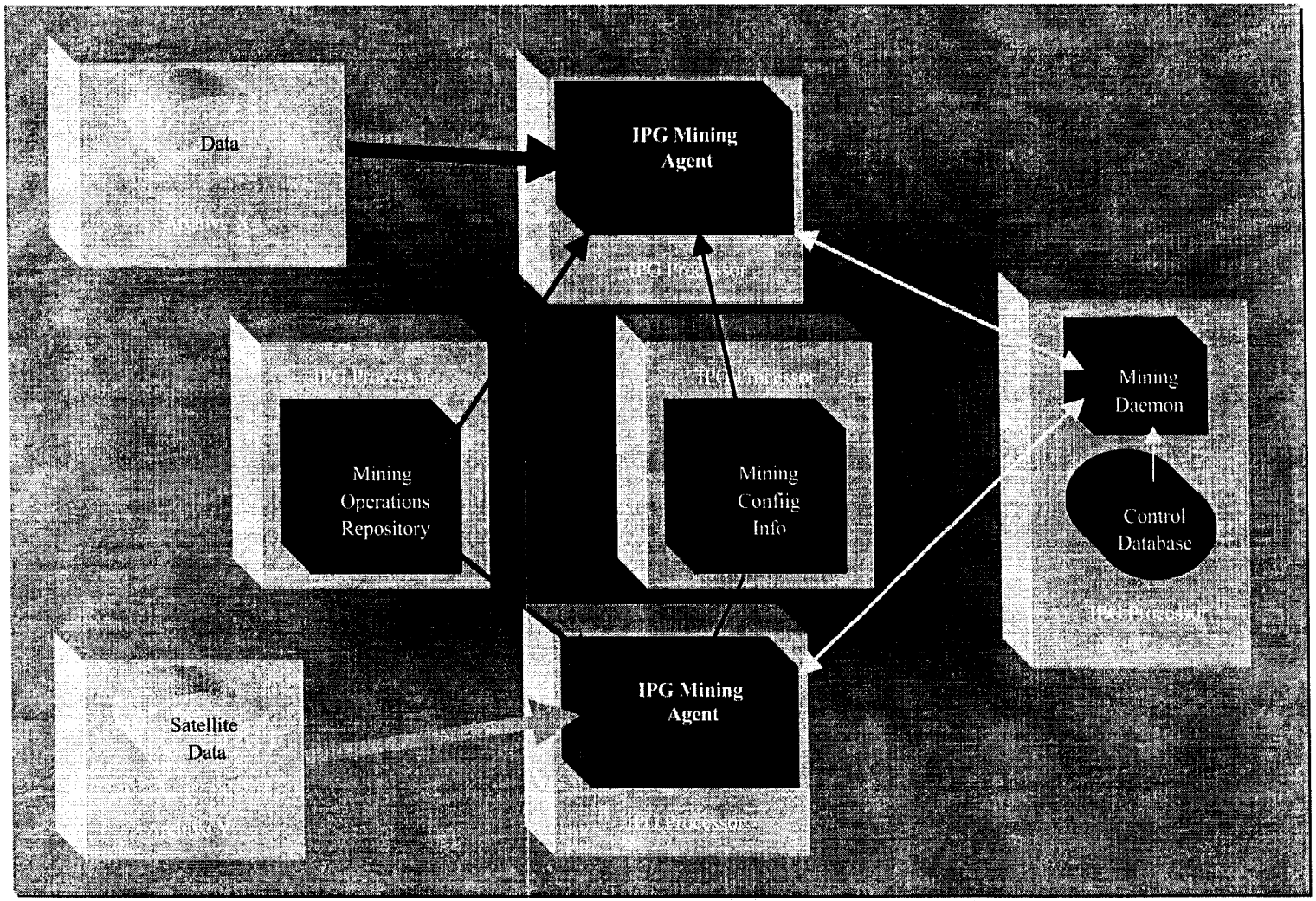
# Why Use a Grid for this Application?

- NASA has large volume of data stored in its archives.
  - E.g., In the Earth Science area, the Earth Observing System Data and Information System (EOSDIS) holds large volume of data at multiple archives
- Data archives are not designed to support user processing
- Grids, coupled to archives, could provide such a computational capability for users

# Mining on the Grid



# Grid Miner Architecture



# Proposed mining on the IPG

- User accesses a mining portal to
  - Develop mining plan
  - Identify data to be mined and check file names into Control Database
  - Identify nature of resources required to perform mining
  - Invoke mining system
- Mining portal stages N mining agents to IPG resources

# Proposed mining on the IPG

- Mining agent
  - Acquires configuration information from Mining Config Info server
  - Acquires mining plan from mining portal
  - Acquires mining operations to support mining plan using just-in-time acquisition
  - Acquires URLs of data to be mined from Control Database
  - Transfers data using just-in-time acquisition
  - Mines data
  - Sends results to specified IPG site

# Mining operator acquisition

- Vision is a number of source directories for
  - Public mining operations contributed by practitioners
  - For-fee mining operations from a future mining.com
  - private mining operations available to a particular mining team

# Starting Point for Grid Miner

- Grid Miner reused code from object-oriented ADaM data mining system
  - Developed under NASA grant at the University of Alabama in Huntsville
  - Implemented in C++ as stand-alone, objected-oriented mining system
    - Runs on NT, IRIX, Linux
  - Has been used to support research personnel at the Global Hydrology and Climate Center and a few other sites.
- Object-oriented nature of ADaM provided excellent base for enhancements to transform ADaM into Grid Miner

# Transforming Stand-Alone Data Miner into Grid Miner

- Original stand-alone miner had 459 C++ classes.
- Had to make small modifications to 5 classes and added 3 new classes
- Grid commands added for
  - Staging miner agent to remote sites
  - Moving data to mining processor

## Staging Data Mining Agent to Remote Processor

- globusrun -w -r target_processor '&(executable=$(GLOBUSRUN_GASS_URL)# path_to_agent)(arguments=arg1 arg2 … argN)(minMemory=500)'

# Moving data to be mined

- gsincftpget remote_processor local_directory remote_file

# What Grids Can Do to Support the Earth Science Community?

- Can couple processing to data and data to processing
- Can bring data and processing to users
- Can support services of value to significant portions of the Earth Science Community
  - Mining service
  - Subsetting service
  - Data transformation service -- from one storage format to another

# What Needs to Happen for this to Become a Reality.

- Data archives need to be grid-enabled
  - Connected to the grid
  - Provide controlled access to data on tertiary storage
    - E.g., by using a system such as the Storage Resource Broker that was developed at the San Diego Super Computer Center
- Some earlier-adopter scientists need to be found to begin using the grid
- Grid-enabled tools need to be made available
- Sites could poor computational and data resources and form Earth Science Grid.

## SRB is Existing Tool for Grid-Enabled Archive

- San Diego Super Computer Center's Storage Resource Broker (SRB).
- Permits grid-access to data on tertiary storage
- Supports GSI (Grid Security Infrastructure)
- Provides Unix-like commands for manipulating and accessing data
  - Grid Miner uses
    - Sget -A "RESOURCE='srbresource'" pathwithfile destdir
- Datasets have logical names that are independent of location

# More SRB

- SRB will support data replication of a logical dataset located at different physical locations
- Uses Meta data Catalog (MCAT) for holding data about the data stored in the SRB
- Supports following storage systems:
  - UNIX file system
  - Archival storage systems such as
    - UNITREE
    - HPSS
  - Large objects managed by various DBMS including
    - DB2
    - Oracle

# Grid Funding

- NASA is putting approximately $7 million per year
- DOE's Office of Science is putting at least $7M/yr into Grid software development, deployment of the DOE Science Grid, and several major Grid application integration projects (high energy physics, earth sciences, fusion energy)
- NSF is putting $10-20M/yr into Grid software development and several major Grid application integration projects – e.g.
  - National Earthquake Engineering Systems Grid (bring all major US earthquake engineering instruments onto a Grid)
  - National Virtual Observatory (a Grid application to provide uniform access to all major astronomy datasets)
- NSF is putting $50M/yr into its new Grid based supercomputer centers (Distributed Terascale Facility)
- UK eScience Grid is building a UK-wide science Grid ($50M/yr )
- European Union Data Grid (high energy physics) $7M/yr,
  EU GridLab (numerical relativity) $3M/yr, + others

# Global Grid Forum

- Where did it come from
- What is it
- Why is it important to this community

# Global Grid Forum History

- Grew out of series of workshops and meetings
  - Five Grid Forum workshops held between June 1999 and October 2000 in North America
    - First Workshop held at NASA Ames Research Cener
  - European Grid Forum (eGrid)
    - Two European Grid (eGrid) Workshops held, April 2000 and August 2000
  - SC'98 and SC'99 Birds of a Feather meetings
  - Middleware workhop held at Northwestern University in December 1998 with participation by Grid and Internet experts
  - Grids'98: Designing, Building, and Using a National-Scale Grid", held in Chicago, July 27-28, 1998, brought together for the first time representatives of the various national Grid efforts.

# Global Grid Forum Now

- Represents merger of grid technical communities in North America, Europe and Asia Pacific
- Meets three times per year, alternating between North America and Europe and soon Asia/Pacific
- Modeled after IETF (Internet Engineering Task Force, which sets Internet standards.
- Now 450 people from 35 countries working on Grid technology and standards
- GGF5 meets from 21-25 July 2002 in Edinburgh, Scotland, UK

# Global Grid Forum

- Supports mechanism for formal review, approval and release of
  - Best practices guides
  - Grid standards
- Organized into two types of groups
  - Research Groups which coordinate research on future grid needs
  - Working Groups that are expected to produce best practices documents and standards

# GGF Working Groups

- Grid Object Specification (GOS)
- Grid Notification Framework (GNF)
- Metacomputing Directory Services (MDS)
- Grid Security Infrastructure (GSI)
- Grid Certificate Policy (GCP)
- Advanced Reservation
- Scheduling and Resource Management
- Scheduling Dictionary
- Scheduler Attributes
- Grid Monitoring Architecture
- Network Monitoring
- JINI
- NPI
- OGSI
- GridFTP

# GGF Research Groups

- Relational Database Information Services (RDIS)
- Grid Protocol Architecture (GPA)
- Accounting Models (ACCT)
- Data Replication
- Persistent Archives
- Applications & Test beds (APPS)
- Grid User Services (GUS)
- Grid Computing Environments (GCE)
- Advanced Programming Models (APM)
- Advanced Collaborative Environments

# Application & Test Beds Research Group

- "The GGF Applications Research Group seeks to provide a bridge between the wider application community and the developers and directors of grid policies, standards and infrastructures." [APPS Web Site]
- This would be one place where the Earth Science Community could inject Earth Science unique requirements into the evolving Grid developmemt efforts.

# Why is the Global Grid Forum Important to the Earth Science Community

- It will result in grid standards
  - It will encourage commercial products since there will be standards which the products can meet
  - Products that meet accepted standards should be more marketable
- It provides a forum to get Earth Science-specific requirements interjected into the grid development efforts